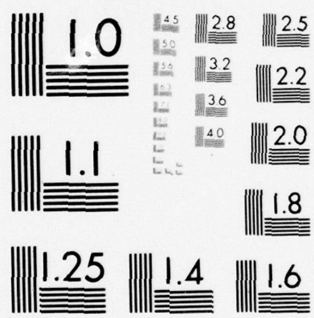
AD-A039 592 ROCKWELL INTERNATIONAL COLUMBUS OHIO MISSILE SYSTEMS DIV F/G 1/3
ARPV SYSTEM/DESIGN TRADE STUDY REPORT. VOLUME VIII. MAINTENANCE--ETC(U)
APR 76 F33657-75-C-0518

UNCLASSIFIED C76-1324/034C-VOL-8 NL

1 OF 1
ADA039592



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A039592

①
NW

Rockwell International

ASD 77-0082

Rockwell International Corporation
Missile Systems Division
4300 East Fifth Avenue
P. O. Box 1259
Columbus, Ohio 43216

(14) C76-1324/034C - Vol-8

(6) ARPV SYSTEM/DESIGN TRADE STUDY REPORT.

VOLUME ~~VIII~~. MAINTENANCE, LOGISTICS AND TRAINING.

CONTRACT ~~NO.~~ (15) F33657-75-C-0518

ROCKWELL INTERNATIONAL
MISSILE SYSTEMS DIVISION

(11) 26 APRIL 1976

(12) 51p.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The Maintenance, Logistic Support and Training concept developments are especially important for ARPV system definition since previous experience with high sortie rate RPV operations of the type required does not exist. Much of the analysis conducted on this contract in these areas is documented in the Reliability/Maintainability Allocation, Assessment and Analysis Report and the Integrated Support Plan (CDRL AOOB and CDRL AOOC). These reports include time lines detailing ARPV Turn-Around-Time (TAT) and ARPV preparation time for storage to operationally ready status, Qualitative and Quantitative Personnel Requirements (QQPRI) and a summary of peculiar support equipment requirements.

This volume documents trade studies in the following areas:

- Basing Concept
- Logistics Concept - Overall Concept Development
- Storage/Packaging Concept
- Maintenance Concept
- Training Concept
- Avionic Support Equipment Concept

2.0 BASING CONCEPT

2.1 CONSIDERATIONS

The ARPV operating base concept was selected after considering five possible alternatives with regard to location, base layout and operational elements considered vital to operational capability. Figure 2-1 illustrates the five alternatives considered and identifies the operational elements associated with each concept.

2.2 ANALYSIS

Evaluation of each concept was accomplished by the identification of factors affecting the acquisition and operation of the base. The factors utilized to evaluate the five basing concepts are:

(1) Geography and Political Feasibility

(2) Cost - Land Acquisition

(3) Launch and Recovery Rates

(4) Operational Vulnerability

(5) Billeting and Administration

(6) Logistics Support

(7) Ease of Deployment

(8) Interference with Tactical Operations

(9) Command and Control

Each of these factors was assigned a weighting factor. The five basic concepts were then evaluated for each factor and assigned a numerical score on a scale of 1-10 with the preferred concept having the higher score. Table 2-1 depicts the factors considered, the weighting factors assigned, the definition of the factors and the appropriate definition of the weighting factor.

2.3 CONCLUSIONS

Table 2-2 depicts the results of the described analysis and clearly illustrates

that Basing Concept #2 offers the most advantages. This Base would be located near a host TAC base, dependent upon the host base for basic services and supply, but independent with respect to ARPV operations. To facilitate this approach, considering that the ARPV operations should be mobile in nature for tactical reasons, mobile maintenance and storage facilities are proposed for OCONUS (Outside CONUS) operations. Figure 2-3 illustrates the facilities envisioned for OCONUS operations which would provide the I level maintenance capability. Standard military vans (Mil-VANS) would be used to house ready-for-issue spares to support operations.

Figure 2-2 illustrates the envisioned facilities required for CONUS operations. These facilities utilize existing capabilities.

BASING CONCEPTS

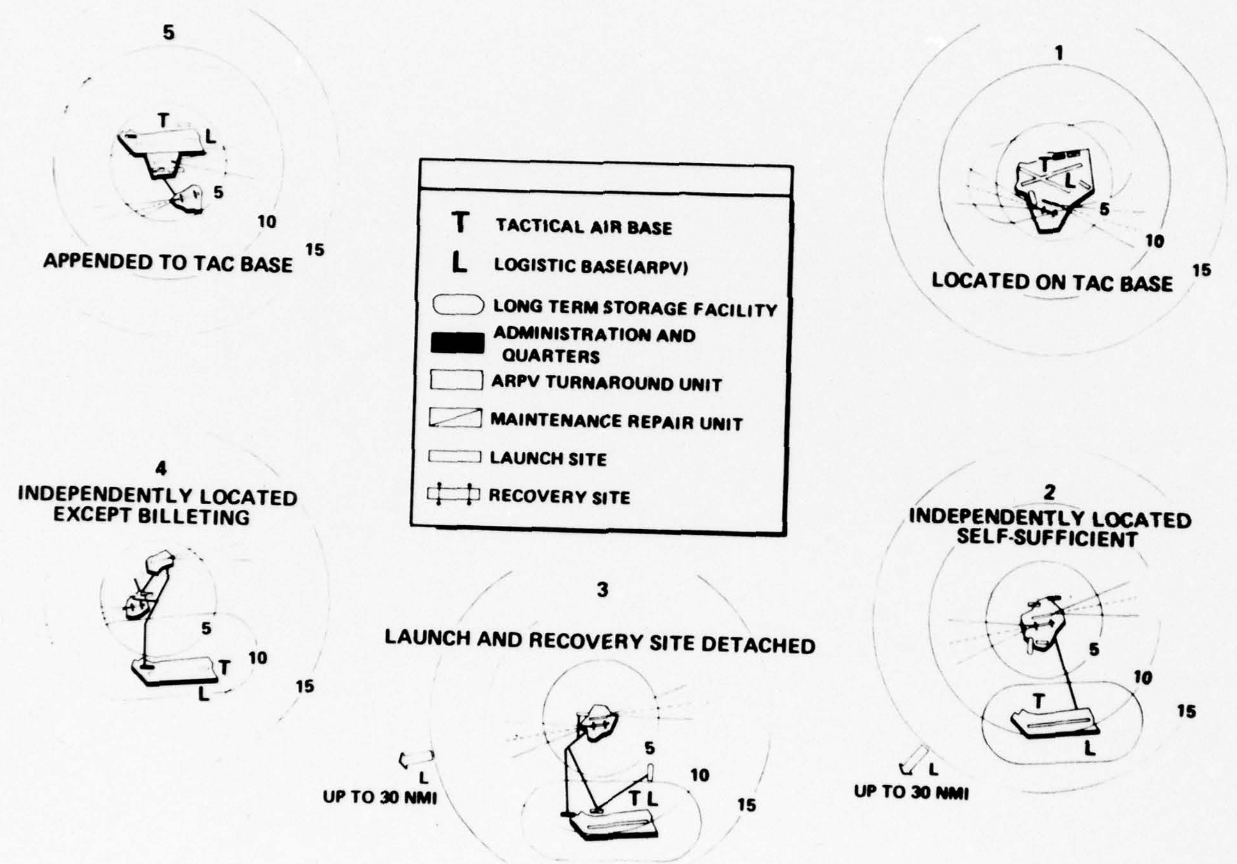


Figure 2-1. Basing Concepts

Table 2-1 ARPV Basing Concepts Descriptor Criteria Definition
(Includes Weighting Factors)

DESCRIPTOR	FACTORS INCLUDED IN DESCRIPTOR	WEIGHT FACTOR	DEFINITION OF WEIGHT FACTOR	DEFINITION OF DESCRIPTOR
1. Geography & Political Feasibility	Terrain Land Availability	15	Rated Medium/High. It either permits development of new bases or restrains operations to existing bases.	Considers adaptability of scenario terrain to launch and recovery operations and ground transport, availability of land where acquisition is required, and resistance of populace to RPV base preparation and activities.
2. Cost	Land Acquisition Construction Housekeeping	20	Rated High. Primary factor in any base development.	Pertains to cost of land acquisition where required, cost of maintenance, storage and billeting facilities where required, cost of additional launch and recovery facilities, cost of non-shared housekeeping and security.
3. Launch & Recovery Rates	Turn-Around Time	20	Rated High. Determines number of RPV's brought to bear against enemy forces.	Capability of base layout to support high launch and recovery rates on a sustained basis rather than just first wave.
4. Operational Vulnerability	Concentration or Dispersion of Assets Security	15	Rated Medium/High. Determines extent of RPV operations following enemy attack.	Susceptibility of base layout to enemy attack or subversion which would cripple or seriously effect ARPV operations.
5. Billeting & Administration	Convenience Efficiency Morale	10	Rated Medium. Affects personnel in sustained RPV operations.	Availability and convenience of billeting and administration facilities with impact on efficiency and morale.
6. Logistics Support	Maintenance & Storage Facilities Time/Distance Between Facilities Host Base Support	10	Rated Medium. Assumes Pre-positioned Assets in All Concepts.	Includes availability of maintenance and storage facilities, distance, road conditions and potential congestion between delivery, storage, maintenance, launch and recovery areas, and availability of host base support personnel and vehicles.

Table 2-1 ARPV Basing Concepts Descriptor Criteria Definition (Includes Weighting Factors) (Continued)

DESCRIPTOR	FACTORS INCLUDED IN DESCRIPTOR	WEIGHT FACTOR	DEFINITION OF WEIGHT FACTOR	DEFINITION OF DESCRIPTOR
7. **Ease of Deployment or Wind-Down**	Proximity to Host Base Reduced Deployment Requirements Due to Host Base Support	7	Rated Low. Relatively little effect on RPV operations following initial movement.	Capability to set up or terminate RPV operations with minimum time, effort and disruption of other tactical activities.
8. **Interference with Tactical Operations**	Traffic Pattern Congestion Communications Congestion Runway, Taxiway and Flight Line Congestion Safety of Personnel and Equipment	20	Rated High. Relatively small amount of interference could seriously degrade both RPV and manned aircraft operations.	Considers base layout with respect to possible RPV intrusion in manned aircraft traffic patterns, and sharing runways, taxiways, flight lines, communications and control facilities. Also considers impact on safety by above conditions.
9. Command & Control	Internal Coordination and Control Functional Flow Patterns	10	Rated Medium. Limited to on-base functions.	Degree of centralized command and control permitted by location of RPV activities.

Table 2-2 Basing Concept Analysis

Wt. Factor	DESCRIPTORS	BASE CONCEPTS 1		2		3		4		5	
15	Geographical & Political Feasibility	6	90	3	45	3	45	2	30	4	60
20	Cost	4	80	2	40	4	80	3	60	2	40
20	Launch & Recovery Raies	5	100	7	140	2	40	4	80	4	80
15	Operational Vulnerability	2	30	4	60	5	75	6	90	5	75
10	Billeting & Administration	6	60	6	60	2	20	4	40	5	50
10	Logistic Supply	6	60	3	30	4	40	3	30	5	50
7	Ease of Deployment or Wind Down	6	42	3	21	5	35	4	28	3	21
20	Interference with Tac. Ops.	1	20	6	120	6	120	5	100	3	60
10	Command & Control	6	60	6	60	2	20	3	30	4	40
127	TOTAL Average		542 4.27		576 4.54		475 3.74		488 3.84		476 3.75
	RANKING		2		1		4		3		5

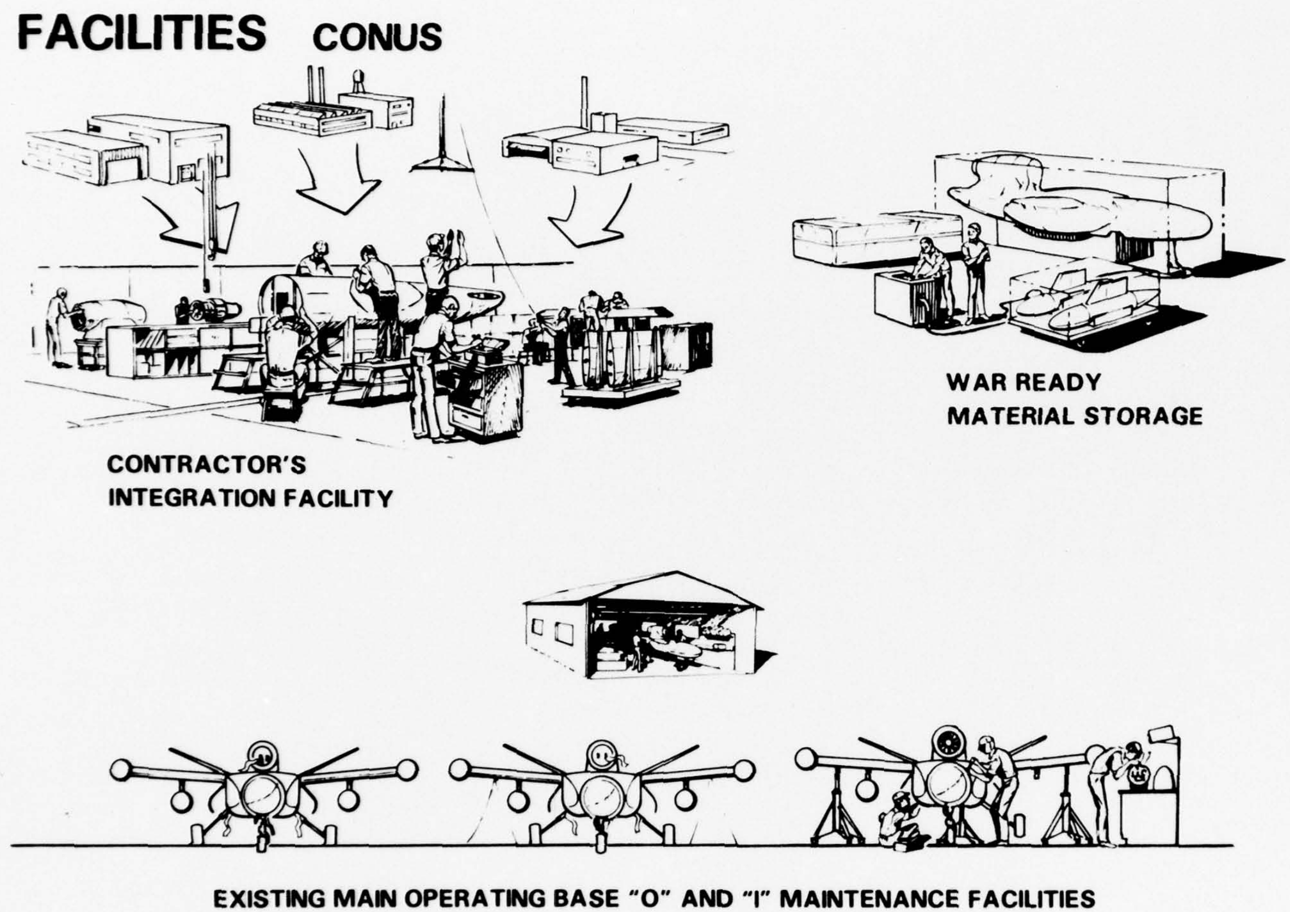


Figure 2-2. Facilities CONUS

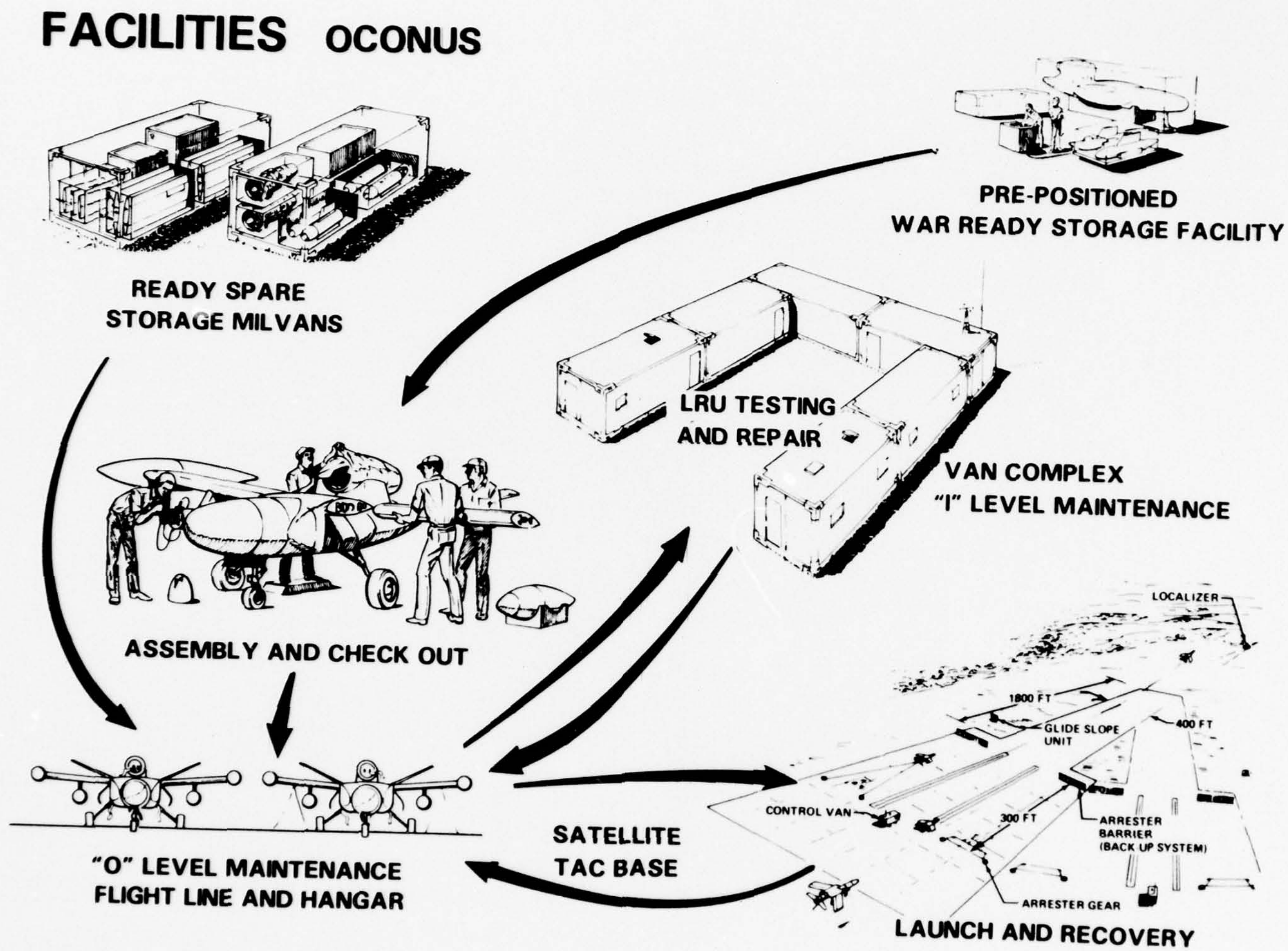


Figure 2-3. Facilities OCONUS

3.0 LOGISTICS CONCEPT - OVERALL CONCEPT DEVELOPMENT

3.1 CONSIDERATIONS

A number of system requirements have direct bearing on the selection of an overall logistics concept. First, and most important, the mission analysis study determined that effective application of the RPV force in the first few days of the conflict is absolutely essential. Second, deployment ground rules specify operating bases OCONUS and in CONUS. Also, all equipment including mobility kits and War Readiness Supply Kits must be air transportable in C-130 and larger aircraft. Finally, since peacetime training will involve a minimum of actual flying due to operational and cost considerations, a significant portion of the total RPV force may be in storage.

Based on these considerations, the following three logistics concept alternatives were evaluated:

(1) Deployment and logistics support of training squadrons in CONUS with War Ready reserve material in CONUS storage.

(2) Deployment and logistics support of training squadrons in CONUS with War Ready reserve material prepositioned in OCONUS storage.

(3) Deployment and logistics support of training squadons in CONUS with War Ready reserve material prepositioned in OCONUS storage with back-up War Ready material positioned in CONUS storage.

3.2 ANALYSIS

Logistics Concept (1) provides the following advantages: (1) a short pipe line for spares; (2) no required duplication of test equipment and associated spares; (3) a wide choice of storage sites; (4) utilization of existing facilities; and (5) protection from destruction due to enemy action. The main disadvantages are the reaction time required to deploy Combat Ready material to the required OCONUS site and the associated problems of priorities for

transportation and establishment of operational sites and capability.

Concept (2) provides the capability of quick reaction to operational demand dependent only on the deployment of operating and maintenance personnel and assembly and check-out time for activating stored vehicles, thus eliminating the transportation and priority problems associated with Concept (1) and the need for establishment of operational sites/ facilities on an emergency basis. The disadvantages of this concept are that a longer pipe line for spares is required to support storage and operating failures and that all resources are exposed to possible destruction at first engagement with no existing back-up capability provided.

Concept (3) provides for a quick reaction to demand by prepositioning Combat Ready material and support spares and test equipment in sufficient quantities to support a short duration engagement. Existing CONUS facilities are utilized for the storage of back-up material while new or existing OCONUS facilities are used to establish an operational capability prior to demand. Disadvantages of this concept are that supporting test equipment and spares must be duplicated for CONUS and OCONUS operations, thus increasing the life cycle cost of the system.

3.3 CONCLUSION

Concept (3), illustrated by Figure 3-1, is the selected ARPV logistics concept. This concept combines the desirable features of Concepts (1) and (2) in that a quick reaction to operational demand is provided and, at the same time, all resources are not committed, thus providing a back-up capability. A long pipe line is required to support a long duration engagement. However, for short duration engagements, turn-around time at the weapon system level is enhanced by prepositioned essential spares for both operational hardware

and supporting test equipment. Existing CONUS facilities are utilized for training and war ready material storage. OCONUS facilities consist of mobile maintenance vans and military vans for storage of selected spares.

ARPV LOGISTICS CONCEPT

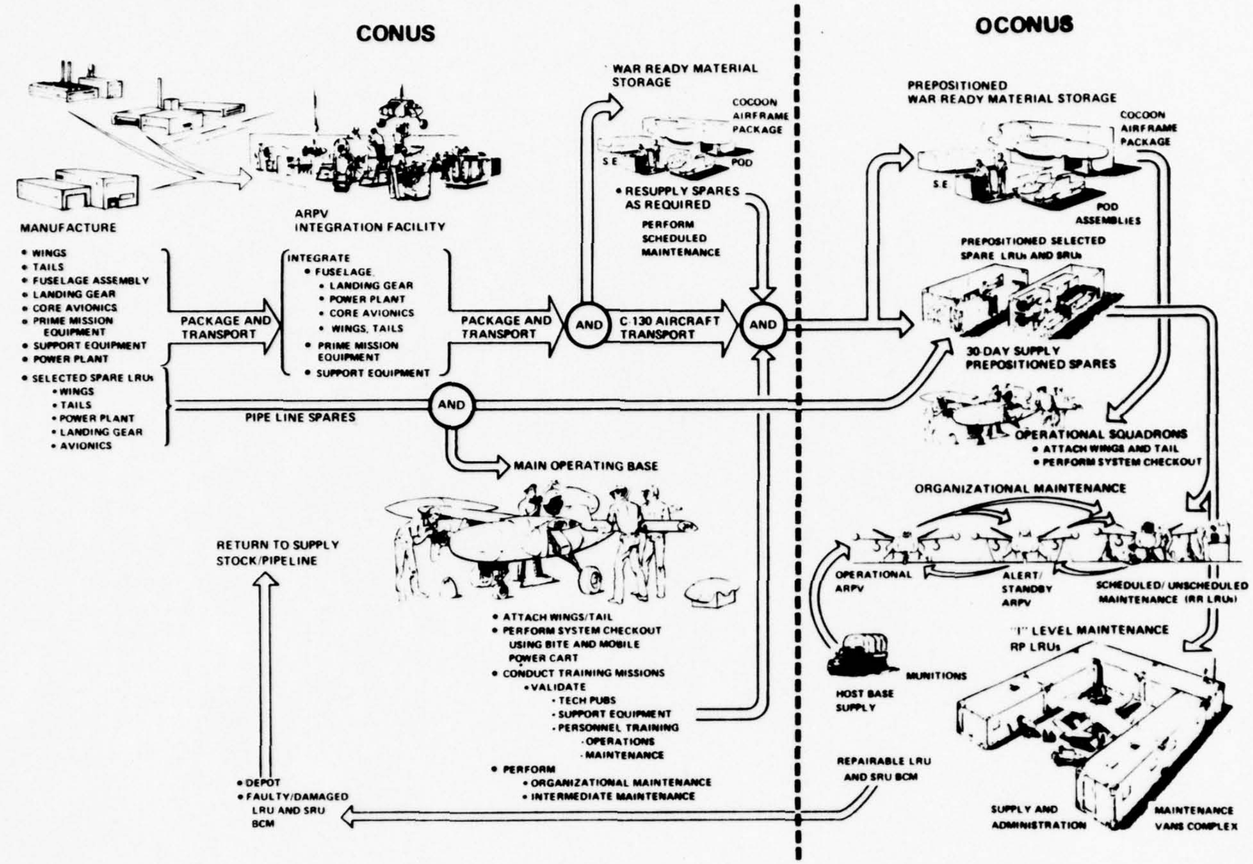


Figure 3-1. ARPV Logistics Concept

4.0 STORAGE/PACKAGING CONCEPT

4.1 CONSIDERATIONS

The storage and packaging requirements are a function of the operational requirements, the adopted Logistics Concept, and life cycle cost considerations. Since many air vehicles and their associated equipment are anticipated to be in storage, time to convert the equipment from storage to an operationally ready status must be minimized. The manpower and equipment required must also be minimized. Testing of stored avionics equipment must be achieved with a minimum of cost and handling.

Based on these storage and packaging requirements, the following concepts were evaluated:

(1) Packaging (Assembly) of discrete assemblies, i.e., fuselage, wings, discrete CORE avionics Line Replaceable Units (LRU), mission pods, mission avionics, etc., for later system build-up.

(2) Packaging (assembly) of major assemblies into discrete units ready for operational utilization with little or no assembly required.

4.2 ANALYSIS

Packaging Concept (1) is not considered a practical approach in that assembly and subsequent testing of the assembled weapon would require an integration facility and capability not normally within the scope of Air Force operations. In addition, this approach would not facilitate a rapid response to operational demand.

Packaging Concept (2) facilitates the requirement for a rapid response to

operational demands in that the weapon is completely assembled and tested prior to storage. To facilitate shipping, handling and storage, the RPV is packaged in modules: the airframe with CORE avionics installed, the wings, the tails, and the mission pods with mission associated avionics.

The airframe module and mission pods are packaged and stored in a cocoon with the capability of avionics testing while in storage without removal of the cocoon. The wing and tail assemblies modules are designed for quick installation and stored in separate shipping crates.

4.3 CONCLUSIONS

Packaging/storage concept (2) provides the required features to implement the overall logistics concept. This concept is depicted in Figure 3-1.

5.0 MAINTENANCE CONCEPT

5.1 CONSIDERATIONS

The mission analysis study identified a requirement for the RPV force to conduct high sortie rate operations. This requirement together with life cycle cost considerations of minimization of manpower and skill level requirements, and support equipment requirements were the primary maintenance concept selection criteria employed.

Development of the ARPV maintenance concept involved consideration of the following four different maintenance policies:

(1) System repair at the organizational maintenance level by fault isolation, remove and repair of the faulty unit and subsequent re-installation of the repaired unit to accomplish system repair.

(2) System repair at the organizational maintenance level by fault isolation to the faulty unit, replacement of the faulty unit with a like item and discarding of the faulty unit.

(3) System repair at the organizational maintenance level by fault isolation to a faulty unit with removal and replacement of the faulty unit and repair of the removed unit accomplished at the Depot maintenance level.

(4) System repair at the organizational maintenance level by fault isolation to the faulty unit removal and replacement of the faulty unit with a like item and repair of the faulty unit accomplished at intermediate maintenance level.

5.2 ANALYSIS

Maintenance policy (2) was discarded due to the cost involved to discard faulty units and to provide spare major/complex units or assemblies. Maintenance policy (3) was discarded for the costs of having excessive spare assemblies on hand to maintain system availability while the faulty units are in the supply pipe line.

Maintenance policies (1) and (4) were then analyzed on the basis of meeting operational requirements for system availability and on the comparative number of spares required for the turn-around-time associated with each maintenance policy.

A 44 percent system operational availability was determined to be required to meet a mission demand rate of 200 missions in a ten-hour day. Maintenance "down time" associated with maintenance policy (1) was determined to be 1.6 hours. The down-time associated with maintenance policy (4) was determined to be 6.0 hours. These parameters will be discussed in detail in the Reliability/Maintainability Allocations, Assessment and Analysis Report, reference CDRL sequence AOOB. Using these parameters, the probability of repair completion within the time constraints and the number of spares required to provide a 90 percent confidence band was determined.

Table 5-1 depicts the determination of the probability of repair completion within the indicated time constraints for maintenance policy.

Tables 5-2 and 5-3 depict the determination of the amount of spares required to be on hand for each of the time constraints noted.

Table 5-1 Maintenance Concept Probability Of Repair Completion

MAINTENANCE POLICY	MTTR (HOURS)	TAT SUPPLY (HOURS)	P REPAIR (1.59 HOURS)	P REPAIR (6.0 HOURS)
REMOVE AND REPLACE				
• Landing Gear Assembly	1.0	0.5	65.0%	98.2
• Landing Gear Component	0.5	0.5	80.0%	99.8
• Wings and Control Assemblies	2.0	0.5	48.0%	91.0
• Wings and Control Components	0.5	0.5	80.0%	99.8
• Power Plant Assembly	2.0	0.5	48.0%	91.0
• Power Plant Components	0.5	0.5	80.0%	99.8
• Core Avionics	0.15	0.5	91.4%	100.0
• Mission Avionics	0.15	0.5	91.4%	100.0
REMOVE, REPAIR, AND REPLACE				
• Landing Gear Assembly	4.0	0.5	29.5%	74.0%
• Landing Gear Components	2.0	0.5	48.5%	98.2%
• Wings and Control Assembly	6.0	0.5	22.2%	59.0%
• Wing and Control Components	3.0	0.5	36.3%	82.0%
• Core Avionics	5.0	0.5	25.2%	65.0%
• Mission Avionics	8.0	0.5	17.4%	50.0%

Table 5-2 Spare Requirements For TAT = 6.0 Hours

ARPV SUBSYSTEM/ASSEMBLIES/COMPONENTS	MAINTENANCE RATE	HOURS USED/ MISSION	NUMBER OF UNITS/ARPV	NUMBER OF ARPV'S	SPARE ASSY'S REQ'D 90% C
Landing Gear Assembly	0.004	0.25	3	22	5
Landing Gear Components	0.018	0.25	15	22	66
Wing/Control Assemblies	0.016	0.75	5	22	66
Wing/Control Components				22	
Power Plant Assembly	0.150	1.25	1	22	3
Power Plant Accessories	0.064	1.25	5	22	22
Core Avionics	.140	.75	14	22	44
*Mission Pod Avionics	0.042	0.25	4	22	44

*4 pods of avionics can be carried at any one time on the ARPV.

Table 5-3 Spare Requirements for TAT = 1.59 Hours

ARPV MAJOR SUBSYSTEM/ASSEMBLIES/COMPONENTS	MAINTENANCE RATE	HOURS USED/ MISSION	NUMBER OF UNITS/ARPV	NUMBER OF ARPV'S	SPARE ASSY'S REQ'D 90% C
Landing Gear Assembly	0.004	0.25	3	22	2
Landing Gear Components	0.018	0.25	15		5
Wing/Control Assemblies	0.016	0.75	5		5
Wing/Control Components					
Power Plant Assembly	0.150	1.25	1		1
Power Plant Accessories	0.064	1.25	5		4
Core Avionics	.140	.75	15		22
* Mission Pod Avionics	.042	0.25	4	22	22

* 4 pods of avionics can be carried at any one time on the ARPV

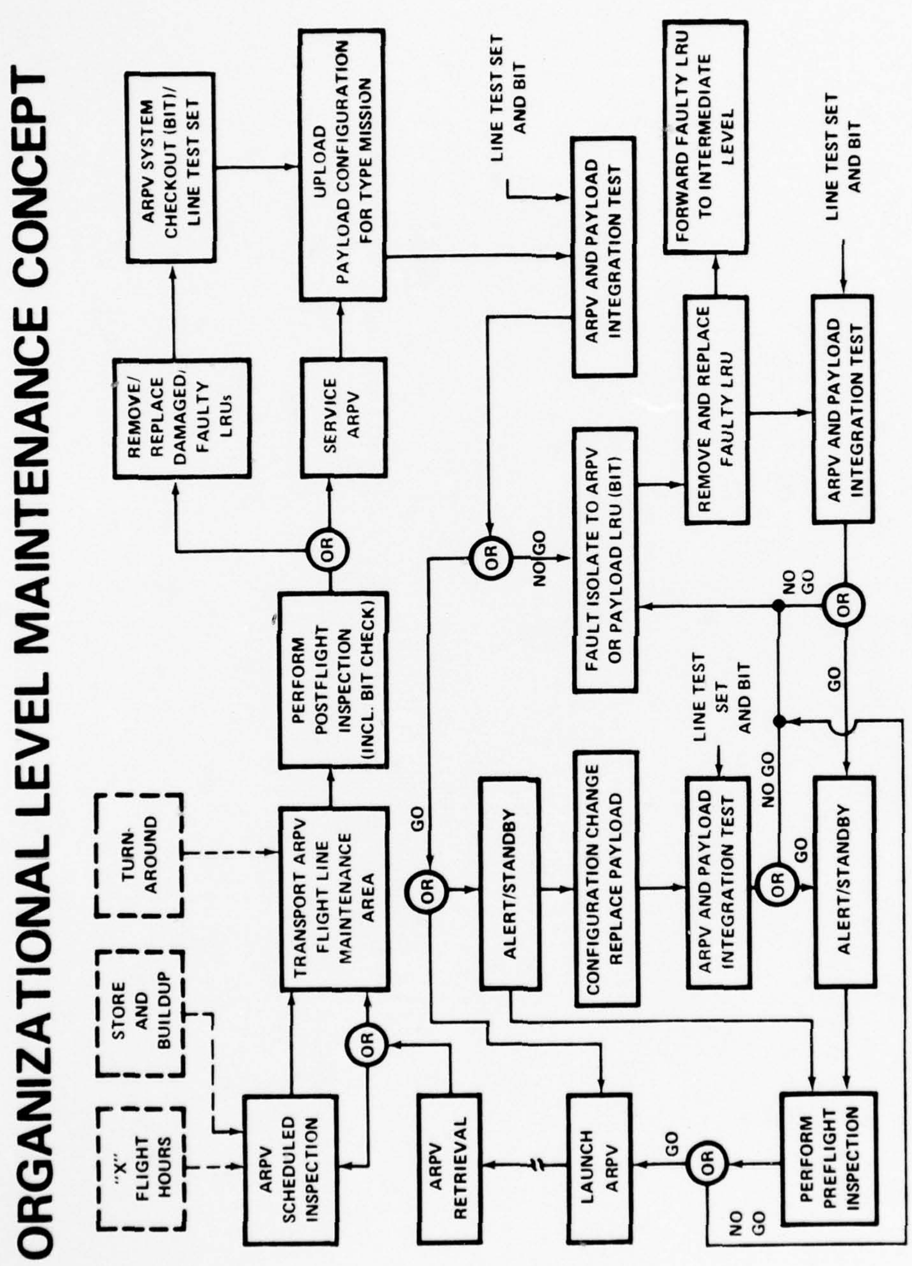


Figure 5-1 Organizational Level Maintenance Concept

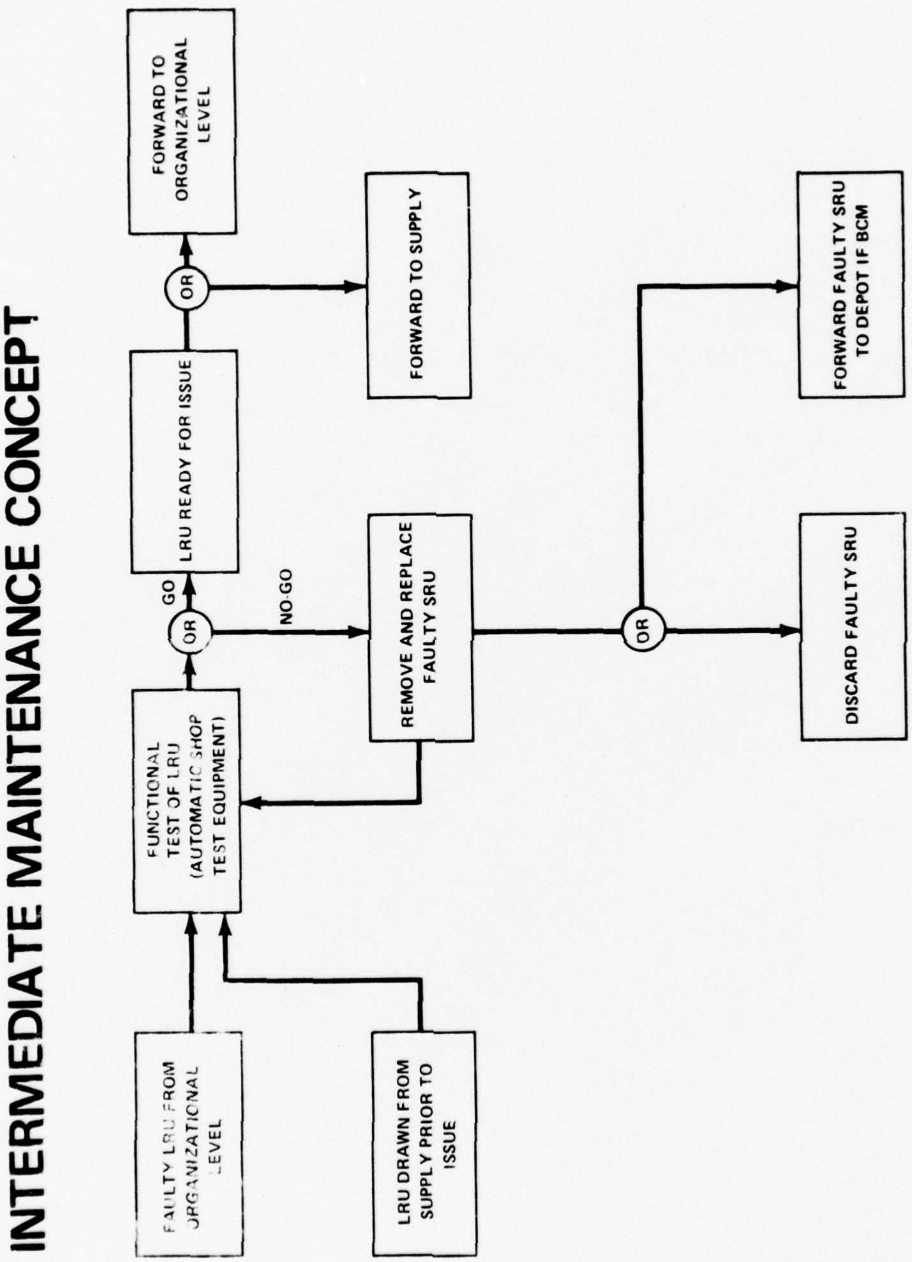


Figure 5-2 Intermediate Maintenance Concept

5.3 CONCLUSIONS

Inspection of the Probability of Repair Completion, Table 5-1, clearly shows that maintenance policy 4 provides the best possibility of maintaining the required system operation availability parameter. Inspection of Tables 5-2 and 5-3, Spare Requirements, also indicates that maintenance policy (4) is the most economical approach.

Figure 5-1, Organization Level Maintenance Concept and Figure 5-2, Intermediate Maintenance Concept, depicts the selected concept based upon the basic maintenance policy of removal and replacement of faulty LRU's at the Organizational maintenance level with repair accomplished at the Intermediate maintenance level.

6.0 TRAINING CONCEPT

Development of the ARPV operations and maintenance training concept evolved from consideration of the alternatives suggested by:

1. Composition of the training staff.
2. Extent of simulation employed in training.
3. Composition of the force to be trained.

In addition, the overall training concept was shaped to conform with equipment delivery schedules and the most expeditious formation of nine combat ready ARPV squadrons along with their supporting elements. Highest priority was assigned to initial training of three squadrons to support the overseas commitment.

6.1 COMPOSITION OF THE TRAINING STAFF

6.1.1 Consideration

The concept of using long term contractor training support was compared with early introduction of an all "blue suit" instructor force.

6.1.2 Analysis

As designer and integrator of the ARPV system, the contractor's engineering staff possesses the inherent sole capability for initial training of service personnel. This training would of necessity be conducted at the contractors facility by training specialists who also will support Initial Operational Test & Evaluation. A cadre of USAF military and civilian technical personnel will be trained for participation in IOT & E and pre-operational activity leading to formation of the first APRV squadron.

The depth of training required to support the "remove and replace" organizational and intermediate level maintenance concepts for the ARPV not only negates the need for prolonged contractor technical assistance, but it also permits deployment of a Field Training Detachment concurrent with attainment of Initial Operational Capability.

Due to the depth of engineering experience required in the early phases of depot overhaul/repair, training by the contractor should continue until the core of USAF technical personnel trained at the contractor's facility has demonstrated capability for performing this task.

Continued training by the contractor beyond IOC, other than special situations at maintenance depots, would appear to be outweighed by advantages of an all "blue suit" training force. The use of military instructor permits unrestricted and optimum use of personnel by providing a dual capability for both combat operations and training. Furthermore, this approach is compatible with current practice, particularly where overseas rotation is involved.

6.1.3 Conclusions

Training staff composition is determined by the requirement to attain an Initial Operational Capability as expeditiously as possible. To accomplish this task:

1. The contractor will provide all operations and maintenance training preliminary to IOT & E.

2. The contractor will train any initial core of depot level maintenance personnel and provide standby assistance as required.

3. A core of contractor trained Air Force training personnel will phase in with a mix of contractor instructors during IOT & E and up to IOC.

4. USAF will conduct all routine operations and maintenance training subsequent to IOC.

6.2 EXTENT OF SIMULATION EMPLOYED IN TRAINING

6.2.1 Consideration

The use of simulation and its effectiveness for training in both operations and maintenance were compared with the advantages and disadvantages of using actual hardware in a real world environment for the same purpose.

6.2.2 Analysis

The large number of ARPV's envisioned in tactical operations will require a proportionally large number of training and proficiency missions for operating personnel. Actual flights for this purpose would be expensive in terms of operating costs and predicted vehicle attrition. Furthermore, any such flights will continue to be restricted to unpopulated areas, which are far removed from overseas deployment sites.

Fortunately, the semi-autonomous ARPV mission is ideally suited for simulation by the inherent nature of its "pinball machine" monitor and control. Actual control consoles could be adapted and programmed to display any variety of missions and associated problems which the operator could not distinguish from "real world".

Launch and recovery can be duplicated to a large extent with timed launch and recovery drills using real hardware. The simulation is not as realistic as in the case of flight control, but it can be combined with actual flight exercises on a spot check basis to provide training and assure proficiency.

Maintenance training which requires on-the-job experience is somewhat more difficult to provide via simulation. However, fault inducement in real hardware can satisfy this requirement if it is implemented in a well discipline program which is careful to avoid any semblance of "make work".

Despite the potential use of simulation for training, actual flights will still be essential for tactics development, particularly in support of manned aircraft strike operations. A limited number of flights may also be generated by a requirement for system equipment verification. Finally, an actual flight check of randomly selected operations and maintenance personnel will remain the ultimate test of combat readiness.

6.2.3 Conclusions

The most cost effective and practical training for ARPV operations and maintenance personnel will combine extensive simulation using operational hardware and a limited number of actual flights.

1. The bulk of flight training will consist of operating real control consoles programmed with simulated missions.

2. Launch and recovery training will consist mostly of timed drills with operational hardware.

3. Much maintenance training, especially the proficiency aspect, will employ fault inducement in real hardware.

4. Overall performance will be spot checked during flights conducted and supported by selected operations and maintenance crews. These flights may be combined with those generated by the need for tactics development and equipment verification.

6.3 COMPOSITION OF THE FORCE TO BE TRAINED

6.3.1 Consideration

The full-time ARPV training squadrons in CONUS and the deployed squadrons would obviously be composed of regular Air Force personnel. However, the composition of four standby squadrons in CONUS dedicated to contingency augmentation of the overseas force was considered with respect to the employment of reservists.

6.3.2 Analysis

To support the overseas wartime contingency, the four CONUS based standby ARPV squadrons must be fully manned regardless of the regular/reserve composition. Since their own assets will be in ready storage and training with the adjacent active squadrons assets will be severely restricted to proficiency requirements, the total training and operational activity will be minimal. For a fully manned regular Air Force organization, overall cost effectiveness would not only be low, but the low level of activity required by such a limited mission would have an adverse effect on morale.

The use of reservists, if available, to man these squadrons would be an ideal solution. The level of training activity required to maintain proficiency would be a challenge to the part time reservists. In addition, any conflict arising from the use of equipment borrowed from the adjacent active squadrons would be resolved in the typical weekend operation of the reserve force. The use of shared assets plus the significantly lower personnel costs of the reserve organization make it very cost effective in this application.

Unfortunately, the manning requirements of four standby ARPV squadrons, com-

posed entirely of reservists, are more than the present population base of the Davis-Monthan AFB area can support. This assumes that the same general ratio of presently organized AF Reserve or AN Guard Squadrons to their adjacent population base is applicable. If the area adjacent to Tucson is extended to 200 miles, then the Phoenix area is included and the total population base could support four standby ARPV squadrons, provided no other organized Air Force Reserve competition is considered. However, this support is based on another assumption, namely that the non-flying ARPV squadron has the same appeal to the reservist as the manned aircraft squadron. Since the inducements of flight are not present, the appeal of the ARPV squadron would probably be less, and the voluntary serve affiliation would be correspondingly reduced.

If an all regular AF standby ARPV organization is not cost effective, and an all reserve unit is not presently feasible, then a mix of the two elements should be considered as the best compromise. Using the present population base of the Tucson-Phoenix area, as well as current trend, a proposed regular reserve manning mix of 50/50 would appear conservative to support the overseas wartime contingency as rapidly as possible. Initial manning would probably be predominantly regular AF, although a weekend training routine to accommodate reservists would be implemented. As reservists are recruited and trained, regular AF personnel are released as replacements for the active squadrons. The mix of reserves to regulars could be adjusted upward as the population base increases.

Precedent for the mix of regulars and reserves has been set in various organizations of Military Airlift Command under the Associate Reserve concept. Success of the Associate Reserve program has resulted in enthusiastic endorsement by the Secretary of the Air Force and Chief of Staff.

6.3.3 Conclusions

A flexible mix of regular and reserve AF personnel appears to be the best solution to manning the four CONUS based standby ARPV squadrons. Reservists would be employed under the Associate Reserve concept. Proposed manning would include the following features:

1. Standby squadrons will be established with core of regular AF personnel.

2. Standby squadron training activities will be geared to accommodate reservists. Shared training assets will be utilized seven days per week.

3. Regulars will oversee initial training of reservists.

4. Qualified reservists will replace regulars on a man-to-man basis. Regulars will serve as replacements in active squadrons.

5. Reservists will remain in CONUS except in emergencies or deployment exercise. Regulars will fit in the overseas rotation cycle.

7.0 AVIONIC GROUND SUPPORT EQUIPMENT

The following trade study is primarily based on work performed by Lear Siegler, Incorporated, Astronics Division and presents the analysis behind the selected avionic ground support equipment concept.

7.1 CONSIDERATIONS

The ARPV system is designed to support very high sortie rates. From these sortie requirements time line analyses may be made and it can be shown that to support the high sortie rates, the avionics system checkout must be limited to under 10 minutes for undamaged vehicles. Additionally, the mean time to repair a vehicle must be less than 1 hour at organizational level and less than 4 hours at intermediate level.

The short time available for turnaround drives the entire ground handling philosophy as well as certain design features of the vehicle. Automated testing is a must. BITE is highly desireable. Small easily handled LRU's are desired over larger integrated single packages to reduce handling difficulty. The ground support equipment interfaces should be simplified to avoid having to take time to make and break many connections. Upload of mission information must be a quick, easy process.

Flight line test equipment must be highly mobile, rugged, reliable, easy to use, and weather-proof. The test equipment itself should not become a significant part of the maintenance problem, requiring little or no calibration. The flight line test should check 90% of the core avionics with no ambiguity and 10% with ambiguity no greater than 2, as a goal.

The full intermediate level shop checkout equipment should be able to handle either the complete vehicle and test to LRU level, or test individual LRU's and isolate faults to the Shop Replaceable unit (SRU) level. This item of

ATE, which we shall call the Shop Test Set (STS), will be used to periodically test and calibrate each vehicle, fully certify a freshly assembled vehicle or a just repaired vehicle. Checkout times must remain at a minimum in order that high sortie rates may be supported.

The STS shall be capable of testing the full core avionics in the vehicle to the following limits:

(a) Test of 95% of system to a confidence level of 95% that all malfunctions have been detected and that the ambiguities between LRU's is held to less than 5%.

(b) Test of LRU's to 100% with a 95% certainty of fault detection and less than 10% ambiguity to identifying faulty shop replaceable units.

(c) Full vehicle test time shall be less than 1 hour.

(d) LRU fault isolation test time is LRU dependent but no LRU (intermediate level) test shall exceed 10 minutes. Most LRU's will require less than 2 minutes.

The STS shall be air transportable, accept standard AC power from military generator sources, and have a self test and verification capability. It shall be easily serviced by use of removeable modules, and easily adaptable to vehicle configuration changes. Software shall be in a HOL language appropriate to test systems.

This study evaluated five approaches towards maintenance support of the vehicle avionics. These consisted of:

(a) Full BITE
(b) Manual Test Sets

(c) Computer Operated Test Sets.
(d) Combination of partial BITE and Computer Operated Test Set
(e) Combination of partial BITE, Computer Operated Test Set, and Manual Flight Line Test Set.

The following paragraphs will describe the options available and discuss important performance, maintenance, and cost parameters that must be considered.

7.2 ANALYSIS

7.2.1 Full BITE

BITE consists of hardware, software, or both added to an avionics unit to perform a self test operation and indicate go-no-go status. Some implementations even indicate failed shop replaceable unit (SRU). BITE rarely checks 100% of a unit especially sensor transducers since the stimulus of the non-electrical parameter being sensed is generally difficult to provide. Items in this category include Air Data systems and inertial systems. Receiver front ends and transmitter outputs are other items that are often not checked. The LSI ARN 101 LORAN, however, is able to check itself from the antenna coupler all the way through with a 1 or 2 PC card add-on since the RF frequency of LORAN is only 100 KH_z and a simple output of the processor clock provides the appropriate test signal. This is an exceptional result rather than the rule.

Increasing numbers of avionics equipments are becoming available with at least some BITE installed, and, where available at reasonable prices - and no performance compromise - they should be considered for ARPV. The development costs of adding BITE to present day equipments to be used by ARPV are generally prohibitive.

The table 7-1 shows a list of the baseline ARPV core equipment and the status of BITE for each item.

Upon reading the table it is obvious that ARPV will carry considerable BITE. It is also obvious that while a large portion can be tested with BITE, that there are certain key items that require test remaining. However, with the on-board computer, a self-test program (initiated from a suitcase tester, for instance), can send commands to the control actuators and observe the position feedback responses, read the barometric altitudes, and observe wind gust activity in the airspeed output. This will leave only the landing gear activation system, the radar altimeter RF sections, and possibly the GPS RF sections untested. These tests are more qualitative than quantitative but a reasonable degree of confidence of operation can be achieved.

Since most units do their own testing and set their own failure flags, the degree of ambiguity is also minimized.

It is also interesting to note that the computer (using surplus KOP/S capability, as dead time, and surplus memory) will run in-flight background self-test. The ARN 101 LORAN also runs a background self-test in time periods between expected LORAN inputs. The MLS Receiver will do a self-test if initiated by the core avionics computer, the last waypoint before landing pattern would be a good place for this. JTIDS uses the beginning and end of each period as a self check while doing appropriate signal time alignment corrections. The three estimates of altitude, inertial, baro, and radar

Table 7-1. BITE In Core Avionics

UNIT	BITE	% TESTED	IN-FLIGHT TEST	%
Computer/Memory	Yes	90%	Yes	90%
LORAN (LSI ARN 101)	Yes	98%	Yes	98%
Strapdown Platform (Teledyne - TDS-3D)	Yes	85%	Yes	65%
Radar Altimeter (Honeywell APN-194)	Yes	50% Data Process Only	No	--
MLS Receiver	Yes	95%	Yes	95%
JTIDS	Yes	95%	Yes	95%
Air Data Rosemount -	No	--	No	--
GPS (Late 80's)	Yes	80%	No	--
Actuator Interfaces	No	--	No	--
IFF	Yes	95%	No	--

can be cross compared to assure that the radar and baro altimeters are reasonably correct (a high accuracy cross check is not possible here). The strapdown platform checks the erection circuits continuously, however, failure of the platform will result in vehicle loss, but the telemetered (Via JTIDS) failure flag during the last seconds of flight may be of some use.

7.2.2 Manual Test Sets

A manually operated test set consists, generally, of a collection of general purpose and special purpose test equipments collected together in a console or rack with various operator conveniences such as central displays, selective switching panels and the like as possible add-on items. The operator follows a printed procedure and manually sets up each test, records the results, and judges the result. The acquisition cost of this type of system is generally lowest, but the time required to perform the tests is large, the chance for error great as is the chance of items tested early in the test failing before the test is over. Additionally, items such as gyros get large amounts of running time and require service more often.

The test can be very complete, and the confidence level of locating the failed LRU can be very high, but degrades the system MTBF.

The labor investment over a 10 year period would be very large. However, the manual tester concept accommodates change in vehicle configuration fairly easily.

The above assumes a full checkout of the avionics in lieu of BITE. As we have seen BITE will exist on ARPV in any case. Thus, a very simple manual

test box to give the flight crew an interface into the core avionics system to read status, initiate selt-test, upload mission, check mission wiring, etc., becomes quite practical. This option will be explored in later paragraphs under combination systems.

7.2.3 Computer Automated Test Systems

In recent years, with the advent of low cost minicomputers, the computer automated test system has come into its own. The manual test equipment is replaced by programmable instruments, and the computer program causes the set up of ranges and scales, directs the connection of inputs and outputs, causes the readings to be taken, times events, makes computations, compares results to stored test limits, signals go or no-go, enters diagnostic routines and identifies the failed unit. Test times are literally reduced to a few milliseconds for individual measurements and the overall accuracy of measurement is generally improved.

Because the time per measurement is so small, most test programs are expanded to do a more thorough test than is feasible with manual methods. The human error factor is vastly reduced, and the wear out of the vehicle is reduced.

Computer operated tests test one item of avionics at a time (or one end-to-end patch), and experience has shown that for vehicles of the nature of ARPV a test time of about 1 hour for a full calibration is required. BITE systems can have several units all churning away at once yielding test times around 5 or 10 minutes. However, BITE cannot detect failures in BITE so the degree of confidence in these tests cannot compare with the full computer automated test. For these reasons, the BITE tests are generally supplemented

with at least periodic full system checks by external equipment.

The full power of computer automated testing in the RPV field is just beginning to be appreciated. The man-hours are reduced, the operator skill level required is lowered, training is simplified. One operator might have several vehicles under test at one time, since, once started, the test systems require little further attention.

The further advantage of computer automated test systems is that tests of incredible complexity are relatively easily performed, whereas if manual methods were used, the test would be dropped as too difficult.

Unfortunately, the computer automated test systems tend to be large, bulky, and environment sensitive. Thus they fit into hangars, transportable shelters, or possibly trucks. As a result they are not as portable as might be desired to support flight line operations. This leads us to some combination systems where the best of each system may be obtained.

7.2.4 Combination of Airborne BITE and Computer Automated Testing

In this combination, some BITE is carried aboard the aircraft, although not complete, and a computer automated test system is employed on the ground for a thorough checkout and fault isolation. The work done by Lear Siegler on the UPDATE program and the follow-on BGM-34C program are examples of this marriage. A preflight self-test program is initiated just before each ground launch, or while flying under the wing of the DC-130 launch aircraft. A full system check with the Shop Test Console (STS) is used before each up load on the DC-130 or ground launch rail. The STS check requires 60 minutes maximum and the prelaunch self check runs about 4½ minutes. Prelaunch self-check is initiated from the flight control operators console, or from a ground launch control panel. Go-no-go results and fail discretes are displayed on these

panels, which technically qualify as "manual testers."

7.2.5 Combination of Airborne BITE, Computer Automated Tester, and Manual Tester

Because the airborne BITE leaves some room for undetected failure, and the Computer Automated Testing takes too long for ARPV sortie rates we are led to seek still further refinements in the flight ready verification process. If one considers that the very fact of recovery of a previously launched vehicle is in itself a clear demonstration of the vehicle's operating condition (assuming no damage upon landing), then the BITE self-test routine takes on added confidence. Thus a highly portable manual test box that can initiate the test, record the results, indicate fail discretes, and upload the next mission data is all that is needed for flight line support. This is along the lines of manned aircraft operational philosophy. The computer automated test equipment would then be used after repair of damaged vehicles, after some prescribed number of successful flights, and after uncrating a new vehicle. For peacetime missions, where high sortie rate is not important, the full computer automated checkout can also be used to obtain the lowest possible vehicle loss rate.

The potential performance of the various ground support approaches for ARPV was evaluated and the results are summarized in Table 7-2. A brief discussion of each of these evaluations follows:

Speed: Full BITE takes approximately 10 minutes and is paced primarily by the alignment of the strapdown platform which requires 8 minutes. Full BITE will not check Air Data sensors other than warm body type of check. Manual test performance is based on past RPV experience. From BGM-34C experience the computer automated tests are paced by 2 items; gyro drift tests and air data altitude

TABLE 7-2 GSE. PERFORMANCE ANALYSIS

PERFORMANCE PARAMETER	FULL BITE	MANUAL TEST SET	COMPUTER TEST SET	BITE & COMPUTER	BITE & COMPUTER & MANUAL
1. SPEED	10 MIN	12 HRS	1 HR	1 HR	5 TO 10 MIN OR 1 HR
2. PERCENT SYSTEM TESTED	80%	95%	95%	95%	80% OR 95%
3. CONFIDENCE LEVEL TO ISOLATE FAILED LRU.	90%	95%	95%	95%	85% OR 95%
4. HUMAN ERROR FACTOR	VERY LOW	VERY HIGH	LOW	LOW	LOW
5. SYSTEM FLEXIBILITY	POOR	GOOD	GOOD	GOOD	GOOD
6. VEHICLE MTBF EFFECT	LOWER	LOWER	SAME	SOMEWHAT LOWER	SOMEWHAT LOWER
7. TRAINING FACTOR	MODERATE	HIGH	MODERATE	MODERATE	MODERATE
8. COST FACTORS:					
a. DEVELOPMENT	HIGH	MODERATE	MODERATE	MODERATE	MODERATE
b. ACQUISITION	HIGH	MODERATE	MODERATE	MODERATE	MODERATE
c. O&M	HIGH	HIGH	MODERATE	MODERATE	MODERATE

and air speed calibration time. Additional time consuming items are tests of flight control time constants, other system timers, and LORAN search and track. For ARPV, several improvements are possible.

(a) Use of a recently available Pneumatic Signal Generator with greatly improved response times, accuracy, and reliabillty.

(b) ARPV's time constants are software rather than analog flight control and do not require special test.

(c) The LORAN used in BGM-34C has no BITE, whereas the ARN 101 LORAN, which could be used for ARPV, does.

Percent System Tested: As noted earlier, BITE does not test all items of the system. External stimuli are required for a good check of air data systems, the radar portion of the Radar Altimeter is not checked, landing gear actuators are not checked, and some RF front ends do not receive complete checking. The manual and computer systems can provide the external stimuli required for all of this, except landing gear and the Radar Altimeter.

Confidence Level To Isolate To Failed LRU: With full BITE, ambiguity is fairly low, but testing with test equipment that is itself untestable lowers the confidence that all failures in that portion of the system that is tested are found. In the last column, the lower confidence level corresponding to the BITE and Manual Test Box, or flight line test portion, results from less complete testing and less complete BITE.

Human Error Factor: BITE and Manual ratings are obvious. The computer operated tests involve more operator interface and chances for error than the BITE option and so the error factor is only "LOW."

System Flexibility: If BITE is a requirement, then options of using other non-BITE-containing equipment are denied, or other methods of testing must be employed. All other methods of support are quite adaptable.

Vehicle MTBF Effect: The excessive test time required by manual test methods wears out the vehicle and results in lower MTBF. The computer automated test methods involve the least additional vehicle equipment burden and acceptably low test times.

Training Factor: The manual test schemes involve the highest training costs. For all other approaches, training is not a large factor. For the computer approaches, the maintenance of software will require only a small number of persons to be trained, since software changes should not be implemented at the squadron level.

Cost Factors: Since full BITE is not presently available, development costs must be carried by ARPV. Acquisition cost increases of the resulting equipments must be multiplied by the total number of vehicles to be built, which is the original squadron count plus the peace and wartime losses. Since the failure rate of BITE equipped equipment is somewhat higher and the equipment cost is higher, O&M costs will be higher. For the Manual options, the test equipment and the vehicle equipment are the least costly, however, manual control panels require design and the test procedures must be written and verified. The console and cabling costs of manual test equipments are on a par with computer automated systems. Therefore manual and computer system are both rated moderate for development and acquisition costs. Manual test systems will be high cost in the O&M phase due to labor costs and higher vehicle wear-out rates.

The performance selection is presented in Table 7-3.

7.3 CONCLUSIONS

Based on the ~~above~~ evaluation, the following is a ranking of the avionic ground support equipment concepts considering both cost and performance:

(1) Combination - BITE, Computer and a Manual Flight Line Test Set;

(2) Full BITE;

(3) Combination - BITE and Computer;

(4) Manual Test Set; and

(5) Computer Operated Test Set.

Table 7-4 provide a summary of characteristics for the selected Flight Line Test Set and the Shop Test Set.

TABLE 7-3 AGE. PERFORMANCE SELECTION

- SELECT...COMBINATION OF BITE, COMPUTER OPERATED TEST SET (ATE), AND MANUAL TEST SET.
- COMBINATION PROVIDES:
    - LOWEST COST SYSTEM
    - RAPID TURNAROUND CAPABILITY
    - THOROUGH TESTING
    - CONVERSION FOR LRU REPAIR AT I LEVEL MAINTENANCE
    - HIGH MOBILITY
    - LOWEST VEHICLE MTBF DEGRADATION

Table 7-4. Test Set Characteristics

FLIGHT LINE TEST SET

- SIMPLE SUITCASE TYPE UNIT - VERY PORTABLE - LOW COST - RUGGED.
- QUICK TURNAROUND - TEST APPROX 5 TO 10 MINUTES - MISSION DATA UPLOAD 3 TO 5 MINUTES.
- PROVIDES:
    - INITIATION OF NON-BOARD SELF TEST.
    - DISPLAYS SELF TEST RESULTS - FAULT ISOLATED TO LRU.
    - READOUT OF ON-BOARD STATUS MONITOR.
    - MISSION DATA UPLOAD.
    - READOUT - FLIGHT COMPUTER MISSION DATA CHECK SUM TEST.
- REQUIRES NO PERIODIC CALIBRATION.
- LOW MAINTENANCE COSTS.

SHOP TEST SET

- COMPUTER OPERATED AUTOMATIC TESTING
    - FULLY ENCLOSED IN MAINTENANCE VAN - REQUIRES NO HANGER
    - CONFIGURED TO TEST MULTI UNITS AT ONE TIME.
    - SIMPLIFIED TESTER-TO-VEHICLE INTERFACE.
- IDENTICAL EQUIPMENT WITH ADAPTERS AND SOFTWARE PACKAGE - REPLACES MANUAL INTERMEDIATE TEST EQUIPMENT - CHECK LRU'S TO SRU LEVEL.
- PROVIDES FULL TESTING OF ALL AVIONICS AND MISSION EQUIPMENT IN APPROXIMATELY 1 HOUR
- CAN PRETEST MISSION EQUIPMENT BEFORE UPLOAD.